CALIFORNIA
ENERGY
COMMISSION

# Alternative Calculation Method For Nonresidential Buildings Solar Heat Gain Coefficient

STAFF REPORT

JULY 2000
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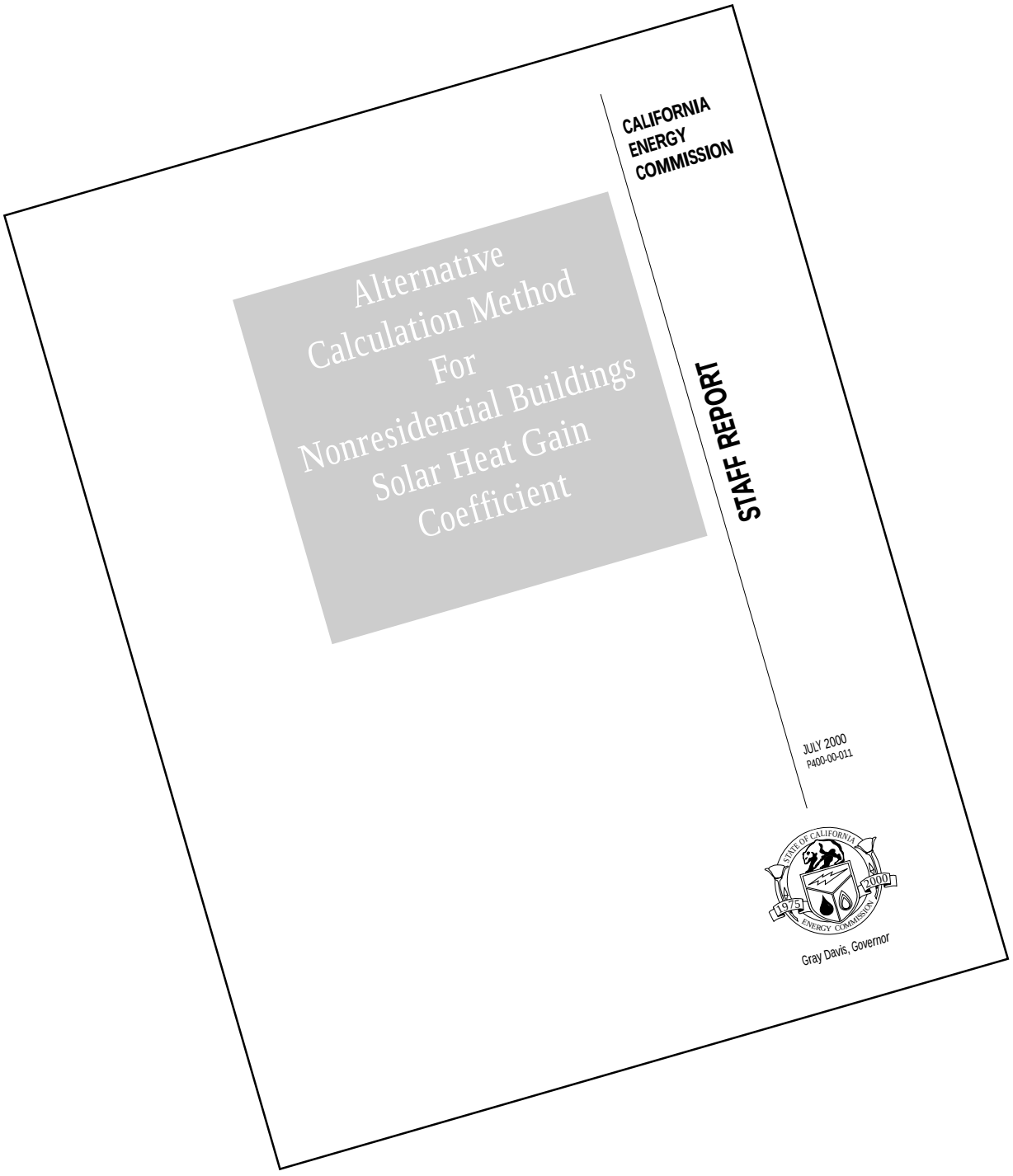
Gray Davis, *Governor*




**CALIFORNIA ENERGY COMMISSION**

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# Nonresidential Solar Heat Gain Coefficient

Alternative Calculation Method

Staff Report

May 19, 1999

## 1 Executive Summary

During the 1998 building efficiency standards rulemaking, the Commission updated the regulations for nonresidential buildings to express the shading requirements for fenestration products in terms of the Solar Heat Gain Coefficient (SHGC) of the entire product, including the frame. Manufacturers of these products were expected to provide Solar Heat Gain Coefficient values to the National Fenestration Rating Council to be published in their certified products directory. Although a joint collaborative effort was expected, manufacturers of glass units and manufacturers of frame assemblies also have not joined together to provide the Solar Heat Gain Coefficient values published in the National Fenestration Rating Council s Certified Products Directory for combinations of their products used in window-wall assemblies. The typical Solar Heat Gain Coefficient for both these types of assemblies are substantially more energy efficient than the values in the default table the Commission adopted as part of its 1998 rulemaking. The result is that an entire class of windows typical of many nonresidential buildings would no longer be available for compliance when the 1998 standards become effective July 1, 1999, leading to a potential difficulty for many of these types of buildings to achieve compliance. Staff proposes that the Commission approve a calculation methodology —suggested by some members of the California Association of Building Energy Consultants and staff in the Windows and Daylighting group at the Lawrence Berkeley National Laboratory— that provides a reasonable method for allowing these combination assemblies to be used in new construction. This approval is consistent with the authority of the Commission to approve Exceptional Methods as described in Section 10-109(b)(4) of Title 24 of the California Code of Regulations.

## 2 Description of Issue

Prior to 1998, the Building Efficiency standards included shading requirements for windows that were expressed in terms of the shading coefficient of the glass alone. This shading coefficient did not account for the effects of the window frames. During the 1998 building efficiency standards rulemaking, the Commission updated the regulations for nonresidential buildings to express the shading requirements for fenestration products in terms of the Solar Heat Gain Coefficient (SHGC) of the entire product, including the frame. This update made the regulations both consistent with the activities of the National Fenestration Rating Council (NFRC) and also consistent with the changes the Commission has pursued for fenestration shading in residential buildings.

In adopting these regulations, the Commission recognized that not all manufacturers participate in NFRC s testing and certification process and that some windows are built at the construction site. To provide a compliance alternative for these manufacturers and for builders who are constructing the fenestration on site, the Commission developed a table of default SHGC values that could be used for compliance purposes. This default table provides a short list of conservatively high SHGC values for a few types of products that can be readily verified by visual inspection. Manufacturers of fenestration products can readily achieve SHGC values substantially lower than the values in the default table. When the manufacturers test these products and certify their performance to NFRC, the manufacturer s certified value can be used to determine compliance with the building efficiency standards. The current NFRC Certified Products Directory does not include SHGC values for most nonresidential fenestration products. Manufacturers of the majority of fenestration products have not provided certified nonresidential SHGC values to NFRC.

Although the strategy of a manufacturer providing certified SHGC values for a fenestration product could work well for fenestration products that are similar to those used in most residences —window frames with glazing installed at a manufacturer s facility— it does not work well with window-wall assemblies commonly used in large nonresidential and small retail buildings. These window wall assemblies are often constructed from frame products from a different manufacturer than the glazing product. No single manufacturer has responsibility for the SHGC for the fenestration product (glazing and frame). Since no manufacturer has responsibility for the entire product, no manufacturer has certified an SHGC to NFRC for these types of products. These types of products are a dominant application of fenestration with low shading values in the current market.

The current regulations and compliance alternatives only allow use of the default SHGC values for all these products that do not have certified SHGC values. These defaults are much too high to achieve compliance for a large portion of nonresidential construction.

The focus of this alternative calculation methodology is to expand available shading alternatives by providing a method for both manufactured fenestration products that include the glass and frame and site-assembled fenestration products to use the SHGC for the glass alone for determining compliance. The proposed method converts the SHGC values for the glass alone into SHGC values for the glass with a typical frame used in this type of construction. The shading value for the typical frame is based on values from the 1997 ASHRAE Handbook of Fundamentals.

# 3 Analysis

## *3.1 Alternatives Considered*

Staff considered three alternatives for allowing fenestration products without certified SHGC values to have a more realistic SHGC value used for compliance. These alternatives were: 1) Conduct a rulemaking to change the values in the default table; 2) Approve an exceptional design to allow builders to use the large table of glass SHGC values published at the back of the NFRC Directory of Certified Products along with a calculation for the effects of framing; 3) Approve an exceptional design to allow builders to use glass manufacturer s data sheets along with a calculation for the effects of framing.

### 3.1.1 Expand the Default Table through Rulemaking Process

Expanding the default table would not meet the Commission s needs or the industry s needs. The character of the default table is to provide an SHGC value for products for which there is no information about the glass and the windows are built on site. Expanding this table to include products that have various tints and films resulting in lower defaults would not be amenable to enforcement by inspection. A rulemaking also does not resolve this issue, since a rulemaking could not be completed in time to meet the needs of the industry. Staff rejected this alternative as not being consistent with the objective of resolving the building community s issues with the limitations of the current default table.

### 3.1.2 Use NFRC Glass Alone Table

This table includes thousands of combinations of glass assemblies. The table includes combinations that mix glass panes from one manufacturer with those of other manufacturers. Many of these mixed assemblies may not be available. If the Commission referenced this table, the builder s compliance personnel would have difficulty selecting a value and knowing that the product is actually manufactured. This uncertainty could lead to enforcement difficulties where a builder would not be able to find a product that met the SHGC value claimed for compliance. It would also be difficult for plan check and field inspection personnel to verify the claimed SHGC against the thousands of values in the directory. Staff rejected this alternative as overly burdensome.

### 3.1.3 Use Glass Manufacturer s Documentation

Using data from the manufacturer provides continuity between those individuals doing compliance analysis, those doing plan check, and those doing field verification. Compliance analysis will be based on the analyst s knowledge of actual products; plan check and field verification can be assured by documentation directly from the manufacturer of the glass products. Staff recommends this alternative as most effectively resolving the described problem.

## 3.2 Exceptional Method Criteria

Section 10-109(b)(4) of Title 24 of the California Code of Regulations provides a method for the California Energy Commission to approve Exceptional Methods for designs, materials, or devices that cannot be adequately modeled using the public domain computer programs. The exceptional method must be supported by theoretical and empirical information that verifies the method s accuracy, must provide documentation that facilitates the enforcement agency s review (Section 10-109(b)(1)(B)), and must include instructions for using the method for determining compliance (Section 10-109(b)(1)(C)).

### 3.2.1 Theoretical and Empirical Information

Fenestration products listed in the *NFRC Certified Products Directory* follow NFRC s procedures for determining the performance values for their products. Manufacturers seeking to acquire energy performance ratings for their products contact NFRC-accredited simulation laboratories. These simulation laboratories use advanced computer tools to determine product performance ratings. Following computer simulations, the highest and lowest performing product within each product line undergo physical testing to ensure that the computer simulations provide an accurate representation of the thermal performance of the complete product line. This testing is performed at NFRC-accredited testing laboratories that have demonstrated their ability to conduct NFRC thermal tests. Once agreement between the simulations and tests is established, manufacturers have product ratings for that entire product line.

Most manufacturers of fenestration products purchase glass or insulated glass units from a manufacturer of glass units, produce a frame, and install the glass in the frame to produce the finished fenestration product. Manufacturers of the glass units, determine SHGC values for their products in a similar fashion to that used for the complete fenestration product, following procedures described in NFRC 200. NFRC requires that all simulations must be carried out using NFRC-certified optical data only. Solar Heat Gain Coefficient must be calculated using spectral transmittance and reflectance in the solar range.

#### *3.2.1.1 Site Assembled Products*

Frames used in site-assembled glass wall assemblies common to nonresidential buildings are usually constructed of metal. According to Chapter 29 of the 1997 ASHRAE Handbook of Fundamentals, the U-factor for the frame of a curtain-wall is 1.8 and the typical frame width is 2.25 inches. If the frame is assumed to be dark, it will have an absorptance of about 0.9 leading to a solar transmittance for this type of material of about 0.55. NFRC 100-97 defines the size for a curtain wall as 80 inches by 80 inches with one vertical mullion. Also according to the ASHRAE Handbook of Fundamentals and NFRC 100-97, an acceptable method for determining the shading value for a fenestration product with this frame type is to weight average the shading values over the glass and the frame. The fraction of the window that is frame for this standard window is 0.136 and the fraction that is glazing is 0.864. Weight averaging these values yields the following equation.

$SHGC_{fen} = 0.136 * 0.55 + 0.864 \times SHGC_c = 0.075 + 0.864 \times SHGC_c$

To be consistent with the accuracy of the data, these terms are rounded to two significant digits. This yields:

$SHGC_{fen} = 0.08 + 0.86 \times SHGC_c$

Where: $SHGC_c$ is the center of glass solar heat gain coefficient for the glass alone, and

$SHGC_{fen}$ is the solar heat gain coefficient for the fenestration including glass and frame.

This method is consistent with the methods typically used to calculate the effects of frames on shading for NFRC and for the ASHRAE Handbook of Fundamentals.

#### *3.2.1.2 Manufactured Fenestration Products*

Frames used in manufactured fenestration products common to nonresidential buildings are also usually constructed of metal. With the exception of the fenestration size, the other characteristics discussed under *Site Assembled Products* also apply to manufactured fenestration products. The fenestration size for these products is 48 inches by 72 inches. Since this window is smaller, the frame makes up a larger portion of the overall assembly. The fraction of frame is 0.194 resulting in a glazing fraction of 0.806. Weight averaging these values yields the following equation.

$SHGC_{fen} = 0.194 * 0.55 + 0.806 \times SHGC_c = 0.107 + 0.806 \times SHGC_c$

Again, to be consistent with the accuracy of the data, these terms are rounded to two significant digits. This yields:

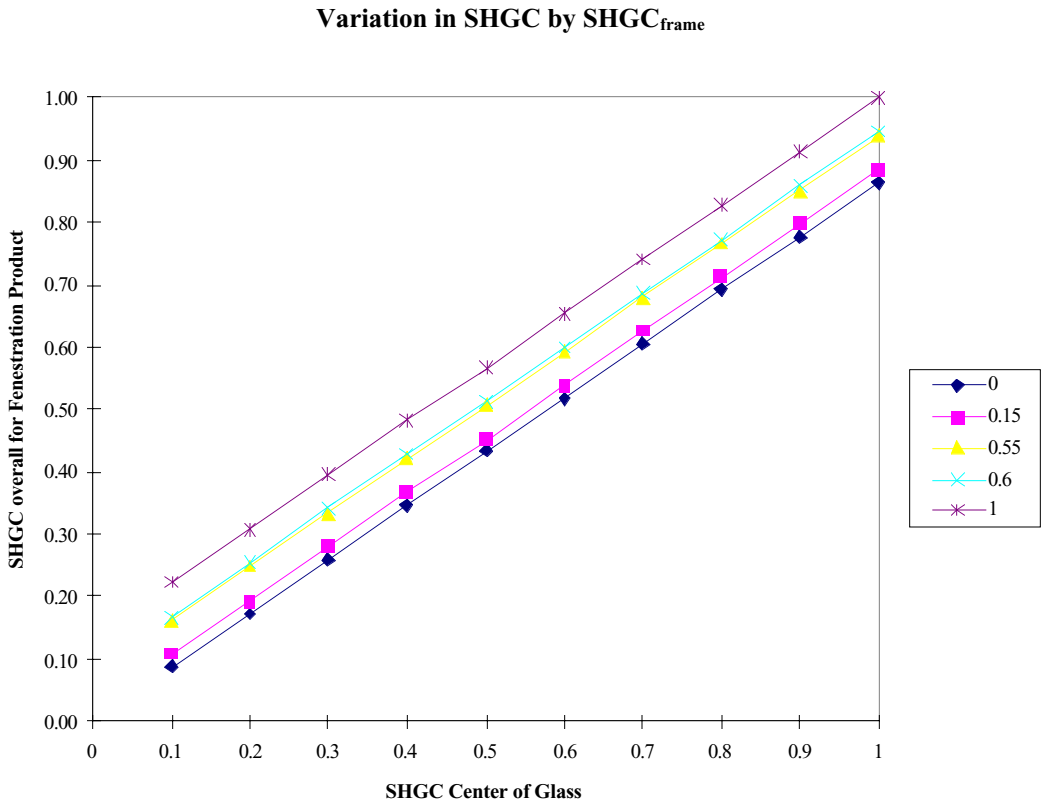
$SHGC_{fen} = 0.11 + 0.81 \times SHGC_c$

Where: $SHGC_c$ and $SHGC_{fen}$ are as described above.

### 3.2.2 Analysis

Examining the method used to develop these two equations suggests these equations are reasonable and that a single equation may be adequate for both manufactured products and site-assembled products. If the $SHGC_c$ is higher than the $SHGC_{frame}$ then the effect of the frame is to reduce the SHGC of the fenestration product to a value less than $SHGC_c$, an improvement in performance when trying to reduce cooling load on a building. If the $SHGC_c$ is lower than the $SHGC_{frame}$ then the effect of the frame is to increase the SHGC of the fenestration product, a decrease in performance when trying to reduce cooling load on a building. When the $SHGC_{frame}$ is representative of the most inefficient frame designs, this calculation method encourages fenestration products with low $SHGC_{frame}$ (better performing) to become NFRC certified and listed in the NFRC Directory while still providing a reasonably accurate SHGC value for high SHGC products. The following chart shows the effects of different $SHGC_{frame}$ values on the overall SHGC of the Fenestration. Note that the lines for $SHGC_{frame}$ of zero and one are only theoretical. They are shown here to bracket the solution —it is impossible to reach these values, let alone go beyond them. The maximum practical value expected for the SHGC of a frame is about 0.60 with a minimum of 0.15. Note the 0.55 value proposed in this calculation method is near the practical maximum. It appears that the

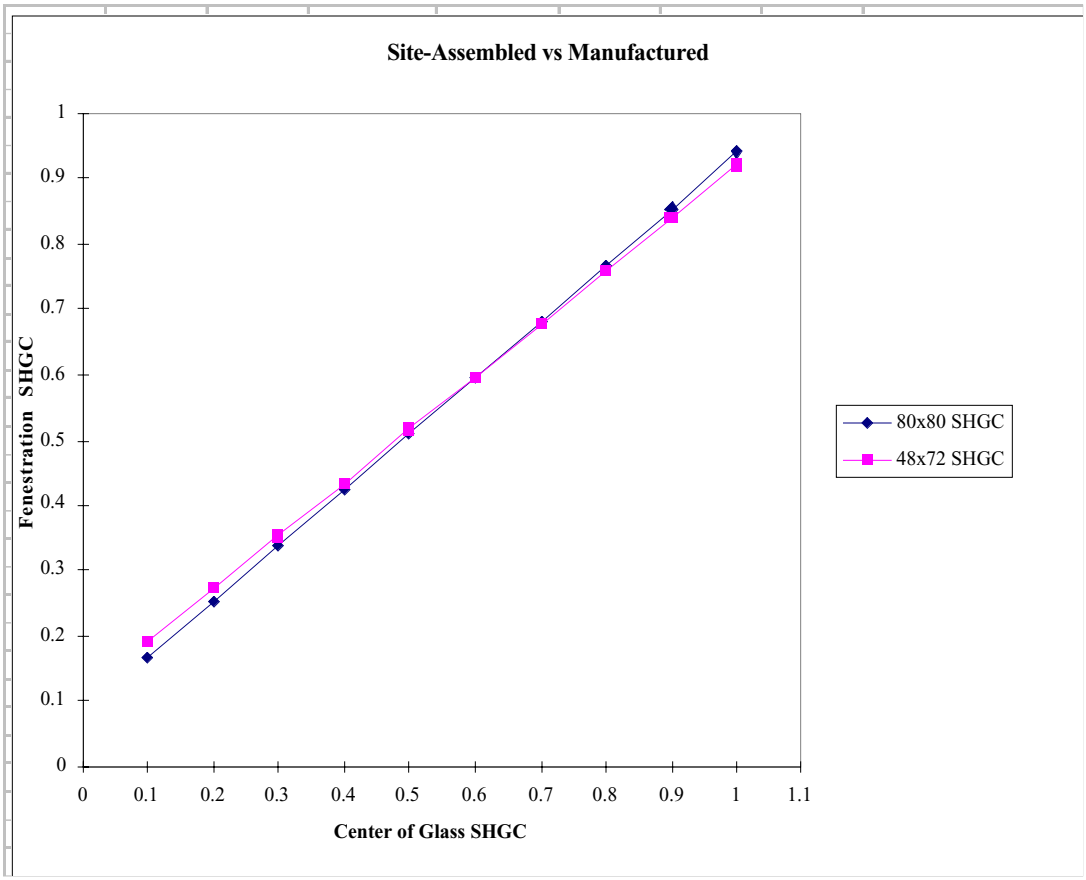
recommended value provides a reasonably conservative estimate of the shading value for the frame.




Having two different calculation methods for nonresidential glass adds substantial complexity to the implementation and verification of the calculation method. On buildings that use both manufactured fenestration units and site assembled units, the compliance, plan checking, construction, and inspection personnel will need to keep careful track of which calculation method applies to each window. Although not an insurmountable burden, it would be preferable to use one method for both types of windows if the size of the error is sufficiently small. Following is a chart comparing the site-assembled (80x80) equation to the manufactured product (48x72) equation for various center of glass SHGC values. This shows the differences in overall SHGC resulting from the difference in percentage framing used in NFRC 100-97. Note that the two lines converge at an SHGC of 0.6, a shading value somewhat higher than that required to meet the standards prescriptive SHGC requirements in cooling dominated climates.

From a practical sense, the range above an Fenestration SHGC of 0.6 is relatively small. Clear, single pane glass has an $SHGC_c$ of about 0.87. The windows at the Energy Commission have an overall SHGC of about 0.61. Fenestration with reflective glass has an $SHGC_c$ of about 0.15 resulting in an overall fenestration SHGC of about 0.21. In cooling dominated climates, the SHGC requirement for East, South, and West glass is

0.44. At this shading value, there is about 1.8 percent difference in shading value between the 80 by 80 window and the 48 by 72 window, a difference in shading points of about 0.01. This is a relatively small value that is within rounding error. Using the same center of glass SHGC, Manufacturers can readily achieve a lower shading value by improving the shading characteristics of their framing and testing and certifying the SHGC for the Fenestration product with NFRC. Using the equation based on the 80 by 80 window provides reasonable results while simplifying compliance to using a single equation.



# 4 Proposed Method

This proposed method applies to fenestration in nonresidential buildings only.

## *4.1 Prescriptive Compliance Method for Nonresidential Buildings*

### 4.1.1 Energy Consultants/Designers/Architects

#### *4.1.1.1 Products with SHGC Certified to NFRC*

If the fenestration product chosen for the nonresidential building is included in the NFRC *Certified Products Directory* Section SV, the SHGC value selected must be entered on the prescriptive ENV-1 form, part 2 of 2. Section SV lists total SHGC of the product (glass and framing) for certified nonresidential products. The SHGC values for these products is determined by a combination of testing and calculating performed for the product manufacturer by NFRC accredited simulation and testing laboratories. The fenestration complies if the proposed total Solar Heat Gain Coefficient is equal to or less than the requirements shown in Table 1-H or Table 1-I of the 1998 *Energy Efficiency Standards for Residential and Nonresidential Buildings*. If requested by the Building Official Plan Checker, Energy Consultants must provide proof of fenestration performance. Providing a copy of the page showing the selected fenestration product from Section SV of the *NFRC Certified Products Directory* is one way of providing this proof. This proof should be included in the compliance submittal to the building department. The energy compliance submittal must clearly indicate the proposed Solar Heat Gain Coefficients for each fenestration assembly in the building.

#### *4.1.1.2 Field-Fabricated Fenestration, Site-Assembled Fenestration and Fenestration Products without SHGC Certified to NFRC*

Field-fabricated fenestration (glass) is a fenestration product whose frame is made at the construction site of standard dimensional lumber or other materials that were not previously cut, or otherwise formed with the specific intention of being used to fabricate a fenestration product. Site-assembled fenestration includes both field-fabricated fenestration and fenestration whose frame is previously cut or formed by a manufacturer with the specific intention of being used with a glass assembly to create a complete fenestration product. Fenestration Products without SHGC certified to NFRC are the same type of products as those that do have SHGC certified to NFRC. The are complete products, shipped from the manufacture with the frame and glazing already assembled. These products may be listed in the *NFRC Certified Products Directory* with their U-factor, but not with SHGC.

For both Fenestration Products and Site-assembled fenestration, which is usually not certified by NFRC, the manufacturers of the glass assembly publish specific information about the SHGC of the glass assembly. Usually this manufacturer documentation provides information about the shading and appearance characteristics of the glass assembly such as the center of glass Solar Heat Gain Coefficient, the color of tints, and the presence of coatings that would effect solar transmittance properties. To determine compliance with the building efficiency standards the center of glass SHGC from the

manufacturer s documentation for the proposed glazing must be converted to an SHGC for the fenestration that includes the framing effect. This converted value is then entered into the prescriptive ENV-1 form, part 2 of 2. The following equation shall be used to convert the center of glass SHGC to the SHGC for the fenestration that includes glass and framing:

$SHGC_{fen} = 0.08 + 0.86 \text{ X } SHGC_c$

Where: $SHGC_c$ is the center of glass solar heat gain coefficient for the glass alone, and

$SHGC_{fen}$ is the solar heat gain coefficient for the fenestration including glass and frame.

If more than one glass type is used for compliance, the $SHGC_{fen}$ must be determined for each glass type. Manufacturer s documentation must be provided for each $SHGC_c$ used for compliance.

The $SHGC_{fen}$ values from the prescriptive ENV-1 form must also appear on the plans. The building plan s window schedule list must indicate the proposed $SHGC_{fen}$ values for each fenestration assembly and these values must be equal to or less than the SHGC values required by the Energy Efficiency Standards, Table 1-H and 1-I. Permit applications must include shading documentation for the Building Official Plan Checker by providing a copy of the manufacturer s documentation showing the $SHGC_c$ and the calculations for $SHGC_{fen}$ as shown above. If using multiple fenestration products or site-assembled fenestration products, include a calculation for each different $SHGC_c$ value attached with each manufacturer s documentation.

#### *4.1.1.3 Mixed Fenestration Types*

If mixed fenestration types are included in the compliance analysis such as installing NFRC certified SHGC values and site-assembled $SHGC_{fen}$ values then the submittal must demonstrate clearly to the building official which fenestration assemblies are certified products and which are non-certified fenestration products or site-assembled fenestration.

### 4.1.2 Builder and Installer Responsibilities

The builder is responsible for assuring that the glass documentation showing the SHGC used for determining compliance is provided to the installer. The builder is responsible for assuring that the persons preparing compliance documentation are specifying products that the builder intends to install. The builder is also responsible for assuring that the installer installs the glass with the same $SHGC_c$ as used for compliance and assuring that the field inspector for the building department is provided with manufacturer documentation showing the $SHGC_c$ for the actual glass product installed. The builder should verify that these fenestration features are clearly shown on the building plans before purchase and installation of the fenestration, glazing and framing products.

### 4.1.3 Building Department Responsibilities

#### *4.1.3.1 Plan Checker*

The building department plan checker is responsible for assuring that the plans identify which fenestration is site-assembled and which is not. The plan-checker is responsible for verifying that the $SHGC_{fen}$ and $SHGC_c$ for site-assembled products is identified on the plans, is consistent with the compliance documentation, has calculations showing the conversion from $SHGC_c$ to $SHGC_{fen}$, and that manufacturer documentation of the $SHGC_c$ has been provided for the fenestration to be installed.

#### *4.1.3.2 Building Inspector*

The building department field inspector is responsible for assuring that manufacturer documentation has been provided for the installed fenestration. The field inspector is responsible for assuring that the $SHGC_c$ for the installed fenestration is consistent with the plans, and the manufacturer documentation is consistent with the product that is installed in the building.

## *4.2 Performance Compliance Method for Nonresidential Buildings*

Each California Energy Commission approved computer program automatically generates an energy budget by calculating the annual energy use of the standard design, a version of the proposed building incorporating all the prescriptive requirements. All information and specifications of the building are collected and entered in the program. The standard design is calculated according to rules and assumptions that are integrated into the computer program and represents the total allowable energy budget for the building. The proposed design must be equal to or less than that of the energy budget for the building to comply. The 1998 Nonresidential ACM Manual requires these computer programs to use the fenestration product SHGC that includes the effects of framing as part of the data entry by the program user, and to print out these inputs as a part of the Performance ENV-1 form.

### 4.2.1 Energy Consultants/Designers/Architects

#### *4.2.1.1 Products with SHGC Certified to NFRC*

If the fenestration product chosen for the nonresidential building are included in the NFRC Certified Products Directory, Section SV, the certified SHGC value is used directly for compliance and entered into the program. Section SV lists total SHGC of glass and framing for nonresidential certified products. The certified SHGC value for the fenestration product is entered into the programs input field for SHGC. The building complies if the total energy use of the proposed design is the same or less than the standard design energy budget. The SHGC values printed on the Performance ENV-1 form must be incorporated into the building plans. The building plan window schedule list must indicate the proposed SHGC values and must be equal to or less than the values indicated in the ENV-1. Energy Consultant/Designer/Architects must provide proof to the Building Official Plan Checker that a reasonable SHGC has been used for compliance by providing a copy of the page from the NFRC Certified Products Directory Section SV for the product that has been used for achieving compliance. This copy of proof should be included in the compliance submittal to the building plan checker for

review. The energy compliance submittal must clearly indicate to the plan checker the proposed SHGC values and features of the glass which are included in the compliance analysis.

#### *4.2.1.2 Field Fabricated Fenestration, Site-Assembled Fenestration and Fenestration Products without SHGC Certified to NFRC*

Field-fabricated fenestration is a fenestration product whose frame is made at the construction site of standard dimensional lumber or other materials that were not previously cut, or otherwise formed with the specific intention of being used to fabricate a fenestration product. Site-assembled fenestration includes both field-fabricated fenestration and fenestration whose frame is previously cut or formed by a manufacturer with the specific intention of being used with a glass assembly to create a complete fenestration product. Fenestration Products without SHGC certified to NFRC are the same type of products as those that do have SHGC certified to NFRC. The are complete products, shipped from the manufacture with the frame and glazing already assembled. These products may be listed in the *NFRC Certified Products Directory* with their U-factor, but not with SHGC.

For both Fenestration Products and Site-assembled fenestration, which is usually not certified by NFRC, the manufacturers of the glass assembly publish specific information about the SHGC of the glass assembly. Usually this manufacturer documentation provides information about the shading and appearance characteristics of the glass assembly such as the center of glass Solar Heat Gain Coefficient, the color of tints, and the presence of coatings that would effect solar transmittance properties. To determine compliance with the building efficiency standards the center of glass SHGC from the manufacturer s documentation for the proposed glazing must be converted to an SHGC for the fenestration that includes the framing effect. The following equation shall be used to convert the center of glass SHGC to the SHGC for the fenestration that includes glass and framing:

$SHGC_{fen} = 0.08 + 0.86 \text{ X } SHGC_c$

Where: $SHGC_c$ is the center of glass solar heat gain coefficient for the glass alone, and

$SHGC_{fen}$ is the solar heat gain coefficient for the fenestration including glass and frame.

If more than one glass type is used for compliance, the $SHGC_{fen}$ must be determined for each glass type. Manufacturer s documentation must be provided for each $SHGC_c$ used for compliance. The proposed design $SHGC_{fen}$ values are entered into the computer program to automatically generate the energy budget of the standard design and the

energy use of the proposed design. The building complies if the total energy use of the proposed design is the same or less than the standard design energy budget.

The $SHGC_{fen}$ output information printed on the Performance ENV-1 form must be listed on the building plans. The PERF-1 and Performance ENV-1 must appear on the plans. The building plan window schedule list must indicate the proposed total $SHGC_{fen}$ values for each fenestration assembly and these values must be equal to the SHGC values listed on the Performance ENV-1 computer form. Permit applications must include shading documentation for the Building Plan Checker by providing a copy of the manufacturers documentation showing the $SHGC_c$ and the calculation for $SHGC_{fen}$ shown above. If the proposed design uses multiple fenestration products or site-assembled fenestration products a calculation for each different $SHGC_c$ value must be attached to the plans along with each glass unit manufacturer s documentation.

#### *4.2.1.3 Mixed Fenestration Types*

If mixed fenestration types are included in the compliance analysis such as installing NFRC certified SHGC values and site-assembled $SHGC_{fen}$ values then the submittal must demonstrate clearly to the building official which fenestration assemblies are certified products and which are non-certified fenestration products or site-assembled fenestration.

### 4.2.2 Builder and Installer Responsibilities

The builder is responsible for assuring that the glass documentation showing the SHGC used for determining compliance is provided to the installer. The builder is responsible for assuring that the persons preparing compliance documentation are specifying products that the builder intends to install. The builder is also responsible for assuring that the installer installs the glass with the same $SHGC_c$ as used for compliance and assuring that the field inspector for the building department is provided with manufacturers documentation showing the $SHGC_c$ for the actual glass product that is installed. The builder should verify that these fenestration features are clearly shown on the building plans before purchase and installation of the fenestration, glazing and framing products.

### 4.2.3 Building Department Responsibilities

#### *4.2.3.1 Plan Checker*

The building department plan checker is responsible for assuring that the plans identify which fenestration is site-assembled and which is not. The plan-checker is responsible for verifying that the $SHGC_{fen}$ and $SHGC_c$ for non-certified fenestration products or site-assembled products is identified on the plans and is consistent with the compliance documentation Performance ENV-1, that calculations have been provided showing the

conversion from $SHGC_c$ to $SHGC_{fen}$, and that manufacturer documentation of the $SHGC_c$ has been provided for the fenestration to be installed.

#### *4.2.3.2 Building Inspector*

The building department field inspector is responsible for assuring that manufacturer documentation has been provided for the installed fenestration. The field inspector is responsible for assuring that the $SHGC_c$ for the installed fenestration is consistent with the plans, the PERF-1 and Performance ENV-1, and that manufacturer documentation is consistent with the product installed in the building.

# 5 Approved Method Form for Site-assembled Products and Fenestration Products without SHGC Certified to NFRC

Use this table for Site-Assembled Fenestration Products and Fenestration Products without SHGC Certified to NFRC

| Fenestration Identification Number on Plans | SHGC for Center of Glass ($SHGC_c$) | Equation for Calculating $SHGC_{fen}$ from $SHGC_c$ | Calculated SHGC for Fenestration ($SHGC_{fen}$) |
|---|---|---|---|
| | | x 0.86 + 0.08 = | |
| | | x 0.86 + 0.08 = | |
| | | x 0.86 + 0.08 = | |
| | | x 0.86 + 0.08 = | |
| | | x 0.86 + 0.08 = | |
| | | x 0.86 + 0.08 = | |
| | | x 0.86 + 0.08 = | |

Plans shall indicate which fenestration is site-assembled or is a fenestration product without SHGC certified to NFRC.

# 6 Sample of Manufacturer Data Cut-Sheet

| | | | | | | | ASHRAE | | Shading | Relative | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Product** | **Transmittance** | | | **Reflectance** | | | **U-Value** | | **Coefficient** | **Heat Gain** | **SHGC** |
| | **Visible** | **Solar** | **U-V** | **Vis-Out** | **Vis-In** | **Solar** | **Winter** | **Summer** | | | |
| VWS 1-08 | 7% | 4% | 2% | 42% | 34% | 34% | 0.31 | 0.32 | 0.12 | 28 | 0.1 |
| VWS 1-14 | 12% | 7% | 3% | 32% | 35% | 27% | 0.31 | 0.32 | 0.16 | 36 | 0.14 |
| VWS 1-20 | 17% | 10% | 5% | 24% | 30% | 21% | 0.31 | 0.32 | 0.2 | 45 | 0.17 |
| VWS 2-08 | 6% | 3% | 1% | 31% | 34% | 16% | 0.31 | 0.33 | 0.11 | 27 | 0.1 |
| VWS 2-14 | 10% | 5% | 2% | 24% | 35% | 14% | 0.31 | 0.33 | 0.14 | 32 | 0.12 |
| VWS 2-20 | 14% | 6% | 2% | 18% | 30% | 11% | 0.31 | 0.33 | 0.17 | 38 | 0.14 |
| VWS 3-08 | 4% | 2% | 1% | 14% | 34% | 15% | 0.31 | 0.33 | 0.11 | 27 | 0.1 |
| VWS 3-14 | 6% | 4% | 2% | 12% | 34% | 13% | 0.31 | 0.33 | 0.14 | 32 | 0.12 |
| VWS 3-20 | 9% | 6% | 2% | 10% | 30% | 11% | 0.31 | 0.33 | 0.16 | 37 | 0.14 |

**Solarscreen Code Chart**
Coating Type
VS = Stainless Steel
VT = Titanium Blue
VA = Antique Silver
VE = Low-E
VG = Gold
VB = Dark Blue
VC = Cinnamon
VY = Crystal Chrome
VH = VH Series

**Outboard Glass Substrate**
1 = Clear
2 = Green
3 = Gray
4 = Bronze
5 = Blue
6 = Blue-Green
7 = Azurlite“
8 = EverGreen“

# 7 Compliance Documentation

## *1.1 Shading Requirements in Building Efficiency Standards*

Windows shall have a relative solar heat gain, excluding the effects of interior shading, no greater than the applicable value in Table 1-H or 1-I.[1] The relative solar heat gain of windows is:

i. The solar heat gain coefficient of the windows; or

ii. Relative Solar Heat Gain as calculated by Equation (1-B), if an overhang extends beyond both sides of the window jamb a distance equal to the overhang projection.

EXCEPTION: The applicable "North" value for relative solar heat gain in Table 1-H or 1-I shall be used for windows:

A. that are in the first story of exterior walls that form a display perimeter; and

B. for which codes restrict the use of overhangs to shade the windows.

EQUATION (1-B) RELATIVE SOLAR HEAT GAIN EQUATION

$$RSHG = SHGC_{win} \times [1 + aH/V + b(H/V)^2]$$

WHERE:

RSHG = Relative solar heat gain.

$SHGC_{win}$ = Solar heat gain coefficient of the window.

H = Horizontal projection of the overhang from the surface of the window in feet, but no greater than V.

V = Vertical distance from the window sill to the bottom of the overhang, in feet.

a = -0.41 for north-facing windows, -1.22 for south-facing windows, and -0.92 for east- and west-facing windows.

b = 0.20 for north-facing windows, 0.66 for south-facing windows, and 0.35 for east- and west-facing windows.

Skylights shall have a solar heat gain coefficient no greater than the applicable value in Table 1-H or 1-I.[2]

[1] California Administrative Code, Title 24, Section 143(a)5.

[2] California Administrative Code, Title 24, Section 143(a)6.

**TABLE 1-H PRESCRIPTIVE ENVELOPE CRITERIA FOR NONRESIDENTIAL BUILDINGS** [3]

**(Except high-rise residential buildings and guestrooms of hotel/motel buildings)**

| | CLIMATE ZONES | | | | |
|---|---|---|---|---|---|
| | **1, 16** | **2-5** | **6-10** | **11-13** | **14-15** |
| **Roof/Ceiling** | | | | | |
| R-value or | 19 | 19 | 11 | 19 | 19 |
| U-value | 0.057 | 0.057 | 0.078 | 0.057 | 0.057 |
| **Wall** | | | | | |
| R-value or | 13 | 11 | 11 | 13 | 13 |
| U-value | | | | | |
| Wood frame | 0.084 | 0.092 | 0.092 | 0.084 | 0.084 |
| Metal frame | 0.182 | 0.189 | 0.189 | 0.182 | 0.182 |
| Mass/7.0≤ HC<15.0 | 0.340 | 0.430 | 0.430 | 0.430 | 0.430 |
| Mass/15.0≤HC | 0.360 | 0.650 | 0.690 | 0.650 | 0.400 |
| Other | 0.084 | 0.092 | 0.092 | 0.084 | 0.084 |
| **Floor/Soffit** | | | | | |
| R-value or | 19 | 11 | 11 | 11 | 11 |
| U-value | | | | | |
| Mass/7.0≤HC | 0.097 | 0.158 | 0.158 | 0.097 | 0.158 |
| Other | 0.050 | 0.076 | 0.076 | 0.076 | 0.076 |
| **Windows** | | | | | |
| U-value | 0.72 | 1.23 | 1.23 | 0.72 | 0.72 |
| Relative solar heat gain | | | | | |
| North | 0.77 | 0.82 | 0.82 | 0.77 | 0.77 |
| Nonnorth | 0.50 | 0.62 | 0.62 | 0.50 | 0.50 |
| **Skylights** | | | | | |
| U-value | 0.85 | 1.31 | 1.31 | 0.85 | 0.85 |
| Solar heat gain coefficient | | | | | |
| Transparent | 0.44 | 0.61 | 0.61 | 0.44 | 0.44 |
| Translucent | 0.70 | 0.75 | 0.75 | 0.70 | 0.70 |

[3] California Administrative Code, Title 24, Section 143

**TABLE 1-I PRESCRIPTIVE ENVELOPE CRITERIA FOR HIGH-RISE RESIDENTIAL BUILDINGS AND GUEST ROOMS OF HOTEL/MOTEL BUILDINGS[4]**

| | CLIMATE ZONES | | | | |
|---|---|---|---|---|---|
| | **1, 16** | **2-5** | **6-10** | **11-13** | **14-15** |
| **Roof/Ceiling** | | | | | |
| R-value or | 30 | 19 | 19 | 30 | 30 |
| U-value | 0.037 | 0.051 | 0.051 | 0.037 | 0.037 |
| **Wall** | | | | | |
| R-value or | 19 | 11 | 11 | 13 | 13 |
| U-value | | | | | |
| Wood frame | 0.063 | 0.092 | 0.092 | 0.084 | 0.084 |
| Metal frame | 0.140 | 0.181 | 0.181 | 0.175 | 0.175 |
| Mass/7.0≤ HC<15.0 | 0.340 | 0.430 | 0.430 | 0.430 | 0.430 |
| Mass/15.0≤HC | 0.360 | 0.650 | 0.690 | 0.650 | 0.400 |
| Other | 0.063 | 0.092 | 0.092 | 0.084 | 0.084 |
| **Floor/Soffit** | | | | | |
| R-value or | 19 | 11 | 11 | 11 | 11 |
| U-value | | | | | |
| Mass/7.0≤HC | 0.097 | 0.158 | 0.158 | 0.097 | 0.097 |
| Other | 0.050 | 0.076 | 0.076 | 0.076 | 0.076 |
| Raised concrete R-value | 8 | * | * | * | * |
| **Windows** | | | | | |
| U-value | 0.72 | 1.23 | 1.23 | 0.72 | 0.72 |
| Relative solar heat gain | | | | | |
| North | 0.77 | 0.82 | 0.82 | 0.77 | 0.77 |
| Nonnorth | 0.77 | 0.82 | 0.62 | 0.50 | 0.50 |
| **Skylights** | | | | | |
| U-value | 0.85 | 1.31 | 1.31 | 0.85 | 0.85 |
| Solar heat gain coefficient | | | | | |
| Transparent | 0.44 | 0.61 | 0.61 | 0.44 | 0.44 |
| Translucent | 0.70 | 0.75 | 0.75 | 0.70 | 0.70 |

[4] California Administrative Code, Title 24, Section 143